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TOBACCO SUBSTATION AT WINDSOR
REPORT FOR 1934

P. J. Anderson, T. R. Swanback and O. E. Street



Connecticut
Agricultural Experiment Station
New Haven

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TOBACCO SUBSTATION AT WINDSOR

REPORT FOR 1934

P. J. ANDERSON, T. R. SWANBACK and O. E. STREET

In presenting this, the thirteenth annual report of the Tobacco Substation, the writers wish first to outline briefly the present status of the work now in progress at the Substation in Windsor.

The time and resources of the staff are divided between (1) scientific research and (2) giving service and information to growers. Under the latter head is included work done in direct response to personal requests of individual growers or of groups of growers. The most time-consuming of all these services is the examination and analyses of soils as a guide to fertilizer needs or to selection of new fields for growing tobacco. Every year over 2,000 soil samples are brought to the Station for various tests, ranging from a simple soil reaction test to determination of six or eight nutrients. These requests have increased enormously in recent years and now demand about one-half of the entire time of one man.

Growers also bring in yearly several hundred samples of tobacco seed to be tested for germination and to have the light seed blown out. Much time is spent in personal conferences with growers who come to the Station for help in solving their problems. For the same purpose personal visits to the farms are often necessary and worth while both from our standpoint and from that of the grower. In this field we have been greatly assisted by Mr. J. S. Owens of the Extension Service at Storrs.

Public talks before groups of growers and conferences with other agricultural workers, the preparation of circulars and bulletins for distribution among them, reaching others by private correspondence and telephone—all are a part of our direct service and take time. Such demands for help have come not only from tobacco farmers but in increasing number from growers of other crops, particularly owners of diversified farms who plant potatoes and vegetables in addition to tobacco. This service, which we have scarcely mentioned in previous reports but which consumes from a third to a half of the time of the staff, is becoming more and more valuable each year as the results of our experiments furnish added information.

Our annual reports have been either records of progress or of final results on some of the long-time field trials at the Windsor Station or on other farms. They also included reports of incidental laboratory and other more technical work. Lack of space necessarily prevented our making full reports on every project every year. Furthermore, as a

usual rule, it seems better not to publish results until tests have been repeated through several seasons.

There are 23 projects, subjects of scientific investigation, on which the staff is engaged. These may be grouped under the following heads:

1. **Fertilizer experiments.** Most of the land on the station farm is occupied by plots on which fertilizers are being tested. During the last 10 years, these tests and the analyses and studies incidental to them have received more attention than any other phase of our work. The purpose of the experiment is to find the optimum quantity of each of the essential food elements that should be applied in the fertilizer and to compare the effect of different carriers of the same element. This involves not only computation and comparison of the weight and of the grade of tobacco from each treatment, but also tests of combustion, taste, aroma and the other factors which make up quality. Also chemical analyses are frequently necessary. Since the fertilizer experiments have been pushed more vigorously than the other lines of investigation, we now have rather definite answers to many of the most urgent questions and are in a position to speak with more certainty on the nutrient requirements of the crop. While there will always be need for some fertilizer experiments, it is anticipated that the emphasis will be shifted gradually to other lines of investigation.

2. **Soil studies.** Fertilizer investigations inevitably lead to studies of the soils to which the fertilizers are added. Consequently there are several projects on soils. By means of lysimeters, the leaching of different nutrients as affected by the type of soil, by the material in which they are supplied, by the season, or by cover crops, is being studied. Soil reaction as affected by change of season and by different fertilizers is a constant subject of study. The effects of added humus, manure, landplaster and other soil amendments are receiving attention.

3. **Nutrition studies** under controlled conditions in greenhouse and laboratory supplement the fertilizer and soil investigations and add to our knowledge of the physiology of the tobacco plant.

4. **Physiological and chemical investigations.** For some years a study has been made of the rate of intake of different nutrients by the plants in the field during the growing season and the transformations that these undergo within the plant. Hundreds of analyses of cured tobacco are also made in connection with the fertilizer studies in efforts to find the causes of defects in commercial crops.

5. **Improvement of strains of Cuban Shade and of Havana Seed by selection and breeding.** In both of these types, strains that are resistant to black rootrot have been developed. Some of these are as good in quality as the ordinary strains and will give a larger yield. They are being tested and further selections made each year at the Station.

6. **Curing experiments.** The effect of variation in humidity, temperature and other environmental factors on the cure and resultant characters of the leaf has long been a subject of study here. Various fuels for raising the temperature of the shed have also been compared. Studies by the Biochemistry Department of the Station on the chemical changes

that occur during curing are also adding much to our understanding of the curing process.

7. Insect investigations. Every kind of insect known to cause any considerable injury to tobacco in Connecticut has been studied by our entomologist, D. S. Lacroix, with the object of finding some method of control or of improving methods now in use. Much time has been devoted to studies of the habits and life histories of the insects, a necessary prelude to discovering the best means of combating them. As a result, we now have practical methods for controlling all insect pests of tobacco with the exception of wireworms and thrips. Failures to control others than these two are usually due to negligence or ignorance of known methods on the part of the farmer. However, the present measures used against wireworms and thrips are not very practical. Therefore particular emphasis is now being placed on their investigation.

8. Study of Diseases. Great progress has been made in combating tobacco diseases in the 12 years since our first report was published. At that time there were three all-important and destructive diseases of tobacco: wildfire, black rootrot and pole sweat. The disease picture is now very different. Wildfire has been practically eliminated. Black rootrot is kept satisfactorily under control by regulation of acidity of the soil and by substitution of resistant varieties of tobacco for susceptible kinds. Methods of controlling pole sweat by firing the curing sheds with charcoal have been investigated and standardized. Today any careful grower can control this disease if he is willing to devote enough attention to it.

However, there is still occasion for more work on pole sweat and the related curing disorders and these investigations are active at present. No new diseases have appeared in the Valley since the advent of wildfire in 1919, but a constant watch is kept for the first appearance of any that are destructive in other tobacco sections but have not yet appeared here.

9. Miscellaneous investigations. There are always some investigations under way which cannot be classified under the preceding eight groups. Most of these are short time projects. Two of them, however, are long-time projects: one on the preservative treatment of shade tent poles which was described in our report for 1933; and the other, the irrigation experiments which can be carried on only during dry years and the results of which are not yet complete.

During the year a general bulletin, "Tobacco Culture in Connecticut," (Bul. 364) designed as a handbook of the industry in this State, has been published and distributed to all growers.

The following pages contain reports on certain projects that are sufficiently advanced to warrant a statement this year.

FURTHER EXPERIMENTS WITH PHOSPHATIC MATERIALS IN THE FERTILIZER

For more than a half century Connecticut tobacco growers have been applying large amounts of phosphoric acid, mostly in various forms of bone, to their land. This was done annually without any definite idea as to how much of this material is needed by the tobacco crops or how much benefit is derived from it. The amount used has been largely a matter of guess-work. Because there were no available data to serve as a guide in practice, the Tobacco Substation conducted a five-year series of field tests, from 1922 to 1926, on a field which had grown tobacco for many years. The object was to determine the optimum quantity to apply and the effects of more or less than this optimum on the crop. This experiment and conclusions drawn from it were published in Bulletin No. 7 of the Tobacco Substation, "The Phosphorus Requirements of Old Tobacco Soils". We refer the reader to this bulletin for a full discussion of the phosphorus problem. The most pertinent conclusions from this experiment were:

1. No special phosphatic materials are necessary in the mixture. Neither the yield nor quality of the crop was improved by them.

2. Old tobacco soils contain large reserves of phosphorus because of the combination of a fairly high native supply, the accumulation from annual over-doses, the absence of leaching of phosphorus from the soil and the very low absorption of it by a tobacco crop.

3. Additional phosphorus in the soil is not absorbed by the plant. Chemical analyses showed no significant differences in the percentage in the leaf regardless of the quantity applied to the soil.

4. The quantity unavoidably supplied with such organic materials as cottonseed meal, which are always included in tobacco mixtures, is sufficient to meet the needs of the crop. Tobacco could be raised satisfactorily on such soils for an indefinitely long period without any special carriers of phosphoric acid.

In the closing paragraph of Bulletin No. 7, however, it was stated that these conclusions would not necessarily apply to new soils not previously cropped to tobacco, and the need of further experimentation on new land was suggested.

Through the purchase of a small tract of land adjacent to the station farm, an opportunity was afforded to repeat this experiment on land which had not previously grown tobacco, at least in recent years. The tests were conducted for five years, 1930 to 1934, and although the results, for reasons mentioned below, are not so conclusive as those from the first experiment, they are sufficiently significant from a negative standpoint to warrant presentation at this time.

The soil is a sandy loam of the Merrimac series with good drainage and uniform in topography. At the start of the experiment in the spring of 1930 the soil reaction was close to 6.00 pH for all plots. The amount of available phosphorus averaged 42 pounds P_2O_5 per acre, variation among the plots being low. This supply of phosphorus was only about one-fourth as large as that on the soil used for the first five-year experiment, but was not so low as we have found in a number of uncropped fields.

The field had not been cultivated and had run to weeds for at least six years. Its history before that is unknown to the writers. It was said to have grown garden crops at one time. Previously an old boundary fence had run diagonally across the field. The soil along this seemed to be richer, introducing an inequality in fertility quite apart from the supply of phosphorus, as shown by the results recorded below.

In the experiment, eight plots, each of one-fortieth acre, allowed for duplication of four different rates of phosphoric acid.

Composition of the fertilizer mixture. An average formula such as good growers use, was chosen for the fertilizer mixture. It supplied 200 pounds of nitrogen, 200 pounds of potash and 42 pounds of magnesia per acre, to *all* plots. The organic nitrogen was from cottonseed meal and castor pomace; the mineral nitrogen from nitrate of potash and calurea. The potash was derived from nitrate and sulfate of potash. At the rate used, the cottonseed meal and castor pomace furnished 54 pounds of phosphoric acid to the acre; therefore even the control plots received some phosphorus. This could have been avoided by using mineral sources of nitrogen only, but since no grower would ever use such a formula, the results would be of no practical benefit. In addition to the supply in the organic materials mentioned, the phosphoric acid applied was divided equally between precipitated bone and superphosphate. The four rates per acre of phosphoric acid under comparison, including that in the organics, were 54, 100, 200 and 400 pounds to the acre. The four different mixtures were as follows:

TABLE 1. COMPOSITION OF THE MIXTURES CONTAINING FOUR DIFFERENT AMOUNTS OF PHOSPHORIC ACID (P_2O_5).

Fertilizer ingredients used in the mixture	Pounds of fertilizer ingredient in mixture which supplied for each acre:			
	54 lbs. P_2O_5	100 lbs. P_2O_5	200 lbs. P_2O_5	400 lbs. P_2O_5
Cottonseed meal	1500	1500	1500	1500
Castor pomace	500	500	500	500
Calurea	106	106	106	106
Nitrate of potash	300	300	300	300
Sulfate of potash	70	70	70	70
Magnesian lime	100	400	100	100
Superphosphate	0	144	456	1081
Precipitated bone	0	60	192	456

The hydrated magnesian limestone used contained about 30 per cent MgO. Since the soil tested rather low in magnesia, 400 pounds per acre of this material was used the first year but reduced to 100 pounds for each succeeding year. The mixtures were applied broadcast to the soil a week to 10 days before setting and then thoroughly incorporated with a disk harrow. Havana Seed tobacco was set about June 1 each year.

Field observations. Growth was not so uniform on this field as could be desired. However, lack of uniformity bore no relation to the fertilizer treatment after the first year. During the first season, tobacco on the plots that had no phosphorus carriers appeared a little less luxuriant than the others. During the entire five years, the largest growth was

along the old fence row. During three of the years, dry weather necessitated irrigation. No consistent differences were noted in the rapidity with which the plants started or developed. The different treatments had no effect on the time of maturity. Those with high phosphorus did not blossom earlier, nor did signs of ripening appear any earlier on the leaves.

TABLE 2. FIVE YEAR SUMMARY OF YIELD AND GRADE INDEXES OF PHOSPHORUS PLOTS.

Quantity of P_2O_5	Plot No.	Acre yield by years						Grade index by years					
		1930	1931	1932	1933	1934	Av.	1930	1931	1932	1933	1934	Av.
54 lbs. (in organics)	P5	1382	1659	1756	1830	1831	1692	.450	.480	.361	.442	.421	.431
100 lbs.	P6	1326	1625	1572	1539	1806	1574	.447	.473	.332	.394	.403	.410
200 lbs.	P7	1512	1670	1691	1763	1851	1697	.402	.453	.349	.443	.381	.406
400 lbs.	P8	1670	1759	1734	1970	1916	1810	.480	.457	.345	.451	.394	.425

The yield. The yield of cured leaf by years (average of two plots in each case) is presented in Table 2. The average of the plots (P8), that received 400 pounds of phosphoric acid annually, is seen to be more than 100 pounds per acre higher than any of the others. This increase, however, was not due to the additional supply of phosphorus but rather to the location of these two plots on the more fertile old fence row. If quantity of phosphorus were the explanation, then the other plots should have shown successive increases in yield with each increase of fertilizer phosphorus. Such, however, was not the case. The P5 plots, with only 54 pounds of phosphoric acid, yielded as heavily as those that had 200 pounds of phosphoric acid. The low yield of the plots that received 100 pounds of phosphoric acid is explained in part by the location of an old apple tree in the corner of one of these plots. There was poor growth directly under this tree and also for some distance from the spread of the branches.

Outside of a small increase in the first year, the experiment gave no evidence that an increase in the phosphorus supply by the addition of superphosphate and precipitated bone has resulted in any increase in yield of cured leaf.

Effect on the grading. After the tobacco was cured, it was graded and sized by experienced sorters in the station sorting shop, and each grade and length was weighed to the quarter of an ounce. By multiplying the percentage of each grade and size by its relative value and adding the products, a grade index is obtained which expresses in one unit the relative grading of each plot. The average (two plots) of each treatment for each year, and for the five years, is shown in Table 2. This table shows that no improvement in grading has resulted from increasing phosphoric acid in the fertilizer.

Effect on some leaf characteristics. There are some characteristics of the leaf which cannot be expressed by figures such as the grade index, but which are apparent to the experienced handler of tobacco. These are important factors in making a leaf desirable for cigar wrappers or binders.

One is the size, color and prominence of the secondary veins. An ideal leaf should have small, soft veins of the same brown color as the rest of the leaf. This gives the uniform smooth appearance necessary for a good cigar wrapper and desirable for a binder. Especially undesirable are veins that are white or lighter colored than the web of the leaf; also veins that are large, or stiff and "wiry", or protrude prominently from the surface of the leaf. Another desirable characteristic is smooth, soft, pliability and elasticity. A leaf lacking in these qualities is called harsh, or coarse.

During the sorting, observations of such characteristics for each plot were recorded. Comparison of the notes on all plots for five years shows that tobacco from plots which received large doses of phosphoric acid are most often characterized by prominent and light colored veins and a harsher texture. The smoothest, most uniform and least "veiny" tobacco was harvested from plots (P5) which received no additional phosphoric acid. This observation coincides with those on the tobacco from the first five-year test, at the conclusion of which the following statement was published (Tob. Sta. Bul. 7. p. 5): "In general, the tobacco from plots which received no phosphorus seemed a little superior in having *less prominent veins*, and the quality was just as good as, if not a little superior to, any of the others."

Just why there should be any connection between the supply of phosphorus and the character of the secondary leaf veins, or harshness of texture, is not apparent, and no explanation is ventured at this time. More thorough physiological and chemical investigating may determine the reason. The more frequent appearance of such undesirable vein and texture on high phosphorus plots has been observed so often during 10 years of experimentation that it could hardly be explained as mere coincidence.

Accumulation of phosphorus in the soil. As stated on page 108, soil samples were taken from all plots before the application of fertilizer the first year and were found to contain an average of 42 pounds of available phosphoric acid (P_2O_5) to the acre, with only slight variation among the plots. Again at the close of the fifth season (October 1934) the Soils Department sampled and tested the plots by the same method as used previously. The amount of available phosphorus found in each plot is given in Table 3. These results show that even on plots which had received *no* phosphatic materials (except 54 pounds per acre in the organic materials) the available phosphorus in the soil had more than doubled in the five years. Each increment in fertilizer phosphorus increased the residual quantity in the soil until the extreme application of 400 pounds P_2O_5 gave a residual supply of more than thirteen times as much as was originally in the soil.

Here is demonstrated again the process by which tobacco fields all over the Connecticut Valley have accumulated such a reserve of available phosphorus that they no longer show any response to further applications.

Amount of phosphorus absorbed by the plant. In the previous five-year phosphorus test, chemical analyses of the leaves revealed that increased applications of phosphorus up to 250 pounds of P_2O_5 per acre, did not increase the quantity which the tobacco plant absorbed. One purpose of the second test was to see whether results would be the same

with higher applications. Samples of the two grades, "darks" (top of plant) and "seconds" (bottom leaves), of the crop of 1934 from each plot were analyzed.

The analyses presented in Table 3 are on air dry samples of unfermented leaves of the fifth crop of the test. These analyses show that the applications of phosphoric acid up to 200 pounds to the acre have not increased the percentage in the crop, even though there has been a considerable accumulation of available phosphorus in the soil. When the application was increased to 400 pounds of phosphoric acid to the acre for five years, there resulted a small increase in the P_2O_5 content of the leaf. Analyses of the tobacco from the first year's crop of this series did not show any increase. The results indicate that by continuous very large applications of phosphoric acid a time will finally arrive when the amount absorbed by the plant will also increase. On account of the differences in original fertility between the plots of this field (as mentioned previously) it is not safe to conclude that the larger yield on these two plots was influenced by the increased phosphorus in the leaf. All our other experiences with phosphorus at the Station lead us to doubt it. The application of such large doses of phosphorus annually (equivalent to 2,500 pounds of superphosphate or more than a half ton of precipitated bone to the acre) is hardly a practical measure and could not be recommended. These results are of scientific, rather than practical, interest.

TABLE 3. AVAILABLE PHOSPHORUS FOUND IN THE SOIL AND PERCENTAGE IN THE CURED LEAF. (AIR DRY BASIS, UNFERMENTED).

Pounds P_2O_5 added annually in fertilizer	Plot No.	Pounds per acre of available phosphorus in soil at end of 5 years*		Percentage of P_2O_5 found in the leaf	
		as P	as P_2O_5	Darks	Seconds
54	P5	50	115	.552	.382
	P5-1	40	92	.587	.400
	Av.	45	103.5	.480	
100	P6	60	138	.587	.335
	P6-1	50	115	.564	.429
	Av.	55	126.5	.479	
200	P7	75	172.5	.511	.400
	P7-1	100	230.	.564	.458
	Av.	88	201.3	.483	
400	P8	200	460	.728	.552
	P8-1	300	690	.750	.517
	Av.	250	575	.637	

*Determined by the Universal Soil Testing Method. See Station Bul. 333.

Effect on the fire-holding capacity. It was also possible to learn whether the rate of application of phosphatic materials has any influence on the burn of the leaves. Samples of the four grades from all plots of the crop of 1933 were tested for fire-holding capacity after they had been fermented and aged for a year.* The average fire-holding capacity of each treatment was as follows:

*For description of method of making burn tests, see Connecticut Agricultural Experiment Station, Bulletin 299, p. 167.

Leaves from plots that received—	(1)	54 lbs. phosphoric acid	burned	58 seconds
	(2)	100 "	"	49 "
	(3)	200 "	"	45 "
	(4)	400 "	"	46 "

The time given is the average of 160 tests for each plot. From these results it is apparent that the fire-holding capacity has not been improved by adding special phosphorus carriers. In fact they give fair evidence that the addition of phosphorus carriers has reduced somewhat the fire-holding capacity.

Practical application. Experiments conducted for 10 years have failed to show any benefit in quantity or in quality of leaf derived from the addition of phosphatic fertilizers (superphosphate and precipitated bone) on this type of land, except for a slight increase the first year on new land. These experiments were carried on with painstaking care and attention to detail, and results were measured by every standard practicable. In certain quality characteristics (vein and texture) there is some evidence of impairment rather than improvement through increase of fertilizer phosphorus. During these years we have made laboratory tests of thousands of soil samples from fields of tobacco growers all over the Connecticut Valley. We found the majority of them similar to the soil on the station farm as far as phosphorus supply and availability are concerned. Only occasionally have we found soils that showed a low supply of available phosphorus.

Is it safe, then, for growers of tobacco in general to omit all special carriers of phosphorus from their fertilizer formulas? This would result in considerable saving of money. The question is partly answered by the experience of a considerable number of growers of good tobacco who *have omitted* phosphorus carriers from their formulas in recent years without observing any ill effects. It is our belief that for most of the tobacco fields in the Valley special phosphorus carriers represent wasted money, if not actual harm to the crop. On the other hand, there is an occasional case, particularly in new tobacco fields, on which phosphoric acid is demonstrably beneficial. In order to take care of any such questionable fields, it is suggested that the grower have his soil tested occasionally. A very simple chemical test will show him whether he may expect any benefit from phosphorus. If he mixes his own fertilizer, he may also experiment by leaving the phosphorus out of the mixture on certain test strips to see whether the omission makes any difference in growth, yield or quality of the tobacco. In these years when the profits from tobacco are small at best, the grower must reduce his cost of production to the limit. Certainly he cannot afford to spend money for fertilizer materials which are unnecessary.

FIELD TESTS ON QUANTITY OF FERTILIZER NITROGEN

For many years the standard rates have been 200 pounds of fertilizer nitrogen to the acre on the usual type of sandy tobacco soils, with a reduction to as low as 150 pounds on heavier, more retentive and naturally

more fertile soils. This is based partly on the unpublished results of a series of experiments at the Station and partly on the experience of many good tobacco growers. There still exists, however, a diversity of opinion and of practice. Some growers use as much as 300 or more pounds of nitrogen; less often, some of them try a much smaller amount.

The problem of determining the optimum quantity by field tests is complicated by the existence of several modifying factors. Thus the optimum under one set of conditions may be entirely wrong under another set. For example, the influence of the type of soil has been recognized. A second factor is the character of the season, particularly the amount and distribution of rainfall. Still a third factor is the form of the material in which the nitrogen is supplied.

However, there seemed to be need of a more thorough study than had been possible heretofore, taking advantage of the advances in our knowledge of soil science and experimental technique. Such a test was started on the station farm in 1932. It is planned to continue this long enough to overcome the handicap of seasonal variations. A field which has about average tobacco soil was selected. As opportunity offers, it is planned to extend this to other types of soil. To eliminate the effects of different types of fertilizer materials, especially with reference to leaching, the nitrogenous materials are all organic and there should be no large amount of leachable nitrates at any one time. The following is a progress report of the work as far as it has progressed in three years.

Plan. The soil on which the plots are located is an average Merrimac coarse sandy loam, with a coarse sand substratum, and therefore with good drainage. It is subject to too much leaching in excessively wet seasons and drought in very dry seasons, but not more so than a large proportion of tobacco soils in the Valley. It is level in topography and uniform in type and native fertility, except for one small spot which became apparent after the experiment started.

The field had not grown tobacco for 10 years, but crops of corn, grass and tomatoes had been produced. When it came into the possession of the Station, it had been in grass several years without any fertilizer and was apparently in a low state of fertility. During 1930 and 1931, it was used as a forest nursery for pine seedlings and a very small amount of fertilizer was applied. In 1932 the 15 nitrogen plots were laid out, each one twenty-fifth of an acre in size. This allowed for triplicate plots for five different rates of application of nitrogen: 100, 150, 200, 250 and 300 pounds to the acre. The formula also supplied a uniform rate of application to all plots of 200 pounds of potash, 150 pounds of phosphoric acid* and 50 to 60 pounds of magnesia. The composition of the fertilizer mixtures is shown in Table 4. The desired rates of nitrogen were obtained by varying the quantity of cottonseed meal, linseed meal and dry ground fish. Since each of these materials contains, besides the nitrogen, also some phosphorus, potash and magnesia, it was necessary to equalize these by changing the amounts of cottonhull ash and precipitated bone.

The fertilizers were applied on May 24, 18, and 21, for the three years respectively, and Havana Seed plants were set 8 to 10 days later. Just as soon as the tobacco crop was removed each year, a cover crop of oats

*Phosphorus application because previous cropping system might have depleted the reserve.

was sowed. This remained green until late in November or early December and was plowed under during the first half of the next May.

TABLE 4. COMPOSITION OF THE FERTILIZER MIXTURES USED ON THE QUANTITY OF NITROGEN PLOTS.

Ingredients of the fertilizer	Pounds of ingredients per acre in formulas furnishing nitrogen at rate of:				
	100 lbs.	150 lbs.	200 lbs.	250 lbs.	300 lbs.
Ground tobacco stems	1000	1000	1000	1000	1000
Cottonseed meal	925	1478	2000	2560	3120
Linseed meal	186	300	400	525	613
Dry ground fish	138	220	300	388	460
Cottonhull ash	360	324	300	270	231
Precipitated bone	215	157	100	39	
Magnesian lime	100	100	100	100	100

Field observations. The seasons of 1932 and 1933 were somewhat too dry and the tobacco suffered from drought. This was noticed especially in 1933 when some of the lower leaves "fired" and were lost. But the field was not irrigated in those years. The season of 1934 produced better growth, but a hot, dry period in July necessitated one irrigation on the 20th.

During each year a difference in general color of the plants became apparent in July and increased up to time of harvesting (August 7 to 9). The plots with the lowest nitrogen took on a paler yellow green which became more marked as the season advanced; the lower leaves were distinctly yellow at harvest. The same tendency was present but less marked on the plots which received 150 pounds of nitrogen. At the other end of the scale, the plots with 300 pounds of nitrogen appeared abnormally dark green, while the intermediate plots had a more normal green color. Differences in height of plant or rate of development were not so apparent.

TABLE 5. QUANTITY OF NITROGEN SERIES. YIELD AND GRADING RECORDS OF 1934 CROP.

Nitrogen applied	Plot No.	Acre yield		Percentage of grades								Grade Index	
		Plot	Av.	L	M	LS	SS	LD	DS	F	B	Plot	Av.
100 lbs.	N54	1931	1629	3	3	30	4	31	2	16	11	.364	.188
	N54-1	1505									100	.100	
	N54-2	1453									100	.100	
150 lbs.	N55	1877	1818	7	6	29	6	30	1	15	6	.413	.393
	N55-1	1745		4	4	26	1	30	5	19	11	.353	
	N55-2	1832		6	8	31	2	28	5	15	5	.414	
200 lbs.	N56	2113	1979	10	10	31	2	32	2	12	1	.465	.439
	N56-1	1902		8	8	26	6	37	2	12	1	.430	
	N56-2	1922		7	7	30	2	35	2	14	3	.424	
250 lbs.	N57	2008	1928	8	10	26	6	37	1	11	1	.439	.422
	N57-1	1935		5	7	24	4	41	5	13	1	.395	
	N57-2	1841		7	7	32	3	33	3	13	2	.433	
300 lbs.	N58	2145	2115	6	9	27	3	43	1	11	0	.427	.422
	N58-1	2172		10	8	26	3	42	1	10	0	.451	
	N58-2	2029		4	6	24	6	45	1	13	1	.389	

TABLE 6. QUANTITY OF NITROGEN SERIES. SUMMARY OF THREE YEARS' CROPS.

Quantity of nitrogen	Plot No. (Average)	Acre yield in				Grade Index			
		1932	1933	1934	Av.	1932	1933	1934	Av.
100 lbs.	N54	1547	1573	1629	1583	.157	.394	.188	.246
150 lbs.	N55	1792	1752	1818	1787	.295	.434	.393	.374
200 lbs.	N56	1820	1818	1979	1872	.359	.444	.439	.414
250 lbs.	N57	1838	1770	1928	1844	.346	.433	.422	.400
300 lbs.	N58	1956	1854	2115	1975	.341	.439	.422	.400

Yield of cured leaf. The yield and grading results for the third year are shown in Table 5, and a summary of results for the three years, in Table 6. These show an increase of about 400 pounds to the acre from the lowest to the highest rate of application of nitrogen. The regular increase in yield with each increase of nitrogen is apparent in all plots, except for the N57 plots. The lower average for these plots is explained by the poor yield of one of the triplicate plots. For some unknown reason this plot lagged behind the replicates during each of the three years. If yield alone were most important, it seems that the grower should use as high as 300 pounds of nitrogen to the acre on this land.

Effect on the grading. After discarding border rows, end plants and any diseased or abnormal plants, and counting the remaining plants, the tobacco from each plot was harvested and cured. Next, experienced graders in the station warehouse graded all leaves from each plot separately, according to the usual commercial grades. Grade indices for each year, computed as described on page 110, are given in Table 6. The full grading record for the 1934 crop is shown in Table 5. Observations on leaf characteristics not shown by the grade indices, such as prominence of vein, thickness of web, etc., were also recorded for each plot.

The results on the triplicate plots, as judged by the sorting records and observations each year, were fairly uniform and present a rather clear picture of the effects of different quantities of nitrogen on the final quality and characteristics of the cured leaves. These may be summarized as follows:

Plots with 100 pounds of nitrogen. This quantity of nitrogen is very clearly not sufficient as may be seen both by the reduced yield and the high percentage of dead, yellow, chaffy leaves which made the tobacco practically worthless for cigar purposes. It was also noted that the tobacco from these plots developed green mold (*Penicillium*) along the midribs while in the bundle, a condition that is characteristic of nitrogen-starved tobacco. The high percentage of brokes, shown by these plots in Table 5, represents these yellow leaves, which could not be classified except as brokes.

Plots with 150 pounds of nitrogen. Although the tobacco on these plots was much better, it still showed many dead, yellow leaves and in other ways was not so good as that from the plots that received more nitrogen. It was evident that 150 pounds of nitrogen is not sufficient on this soil.

Plots with 200 pounds of nitrogen. These plots produced the best quality of tobacco of any of the plots as indicated both by the higher grade index and by the observations at time of sorting. The leaves were not yellow nor were they dark, or heavy, or marked by prominent veins, like those from plots with higher nitrogen.

Plots with 250 pounds of nitrogen. Tobacco from these plots was almost as good as that from plots treated with 200 pounds of nitrogen. In general, however, it was a shade darker and the veins were a little more prominent, indicating that there was probably a little excess of nitrogen.

Plots with 300 pounds of nitrogen. These plots produced the highest yield but not the best quality. The leaves were too dark, too thick and "gummy." Prominent veins were much more in evidence than in tobacco from the other plots. The sorting records of the 1934 crop (Table 5) show that there was a higher percentage of the grade "long darks" on these than on any of the other plots.

Conclusions. The questions this experiment sought to answer were: (1) What is the optimum quantity of nitrogen to apply? (2) What is the effect of reducing the amount of nitrogen to less than the optimum? (3) What is the effect of increasing the supply above the optimum? Based on results to date, the answers are: (1) As between the five different rates of application tested, the best quality is produced by using 200 pounds of nitrogen. If one wishes a high yield regardless of quality, 300 pounds is better. (2) As the quantity of nitrogen is reduced, the leaves become more yellow, dead and unsuitable for the manufacture of cigars until a point is reached where they are worthless. Also the yield declines. (3) As the quantity of nitrogen is increased, the leaves become thicker, darker, more gummy and the veins more prominent. The yield is increased chiefly by the increased thickness of the leaves.

On land that is heavier, less leachy and naturally more retentive of fertility, the optimum might well be below 200 pounds to the acre.

LEAF SPOTS

P. J. Anderson

Dead spots that develop on tobacco leaves while still in the field never cure out in the shed. The cells of these spots, already dead, are incapable of passing through the slow chemical and physical changes which are the essential part of the curing process. Neither do they change color materially. Therefore they are nearly as prominent on a cured leaf as on a green one. They remain stiff when the rest of the leaf is made pliable by "casing" and some kinds of spots fall out or break during handling, giving the leaf a ragged appearance and making it unsuitable for wrapper or binder. The presence of any considerable number of spots also affects adversely the taste and aroma.

Yet the presence of a certain type of spot on Broadleaf was at one time considered highly desirable and still is not regarded as a defect. The reason for this preference is discussed below.

For the most part, however, manufacturers prefer uniform leaves without spots or blenishes and will pay a better price for such tobacco. This is especially true of tobacco types grown for cigar binders and wrappers. It is not surprising, then, to find in going back through the literature of tobacco diseases, that the leaf spots were the first to attract attention and were much discussed long before the nature of plant diseases was known. In this article we shall consider all leaf spots as diseases, although some of them, as mentioned above, are not thought harmful. They do not represent one single disease but rather a group of diseases which differ from one another either in appearance of the lesions or in causal agencies. All the types of spots we have in Connecticut occur also in other tobacco sections on different types of tobacco. Fortunately for us, however, a number of severe leaf spot diseases which occur in other sections are not found in Connecticut at all, or are of such rare occurrence as to be negligible.

From the standpoint of causal agency, it is rather remarkable that not one of our spots is produced by parasitic fungi.* Two kinds of spots are produced by parasitic bacteria. One of these was considered of great economic importance a few years ago but is becoming less prevalent; the other has never been serious here.

Two kinds of spots are of virus origin. Besides these, there are two or three types, called physiological spots, which are thought to be due to local maladjustments of cell metabolism or other physiological derangements not perfectly understood. It is not within the scope of this article to discuss those occasional or accidental spots produced by adverse weather conditions such as hail, frost, rain or wind, or by mechanical injury.

During a disease survey of the summer of 1934, the writer had occasion to observe and study six types of spots. The purpose of the present discussion is to describe the symptoms and causes, as far as known, of each of these in such a way that they may be differentiated one from the other. Each is also illustrated with a photograph.

WILDFIRE

Wildfire is considered first because it is the best known of all tobacco leaf spots in Connecticut, and after a little experience no one should confuse it with the other types of spots.

The distinguishing character of the wildfire spot (as shown in Figure 2) is the presence of the yellow halo, a broad, definitely margined band between the dead, round, brown part, and the living, green tissue of the leaf. Only occasionally in old spots in dry weather is this halo lacking, and even then it may be found on *some* of the spots. Wildfire is caused by the invasion of a parasitic bacterium (*Bacterium tabacum*). The disease, its symptoms, cause and control, have been so fully and repeatedly de-

*A possible exception may be the *Fusarium* spot which was found here originally by Slagg on over-mature leaves at base of the plant, but which has not been observed in recent years.

scribed in previous bulletins* of this station that further discussion is unnecessary here.



FIGURE 2. Wildfire. Yellow halos around the smaller spots appear white in the photograph. Larger spots in the upper right run together to make extensive dead patches.

The history of the disease in Connecticut, however, is rather unusual and worthy of comment. It was unknown here previous to 1919. It

*See Bulletins 1, 2, and 4 of the Tobacco Substation and Bulletin 239 and 364 of the Connecticut Agricultural Experiment Station.

appeared suddenly and spread that year and the following few years with a rapidity worthy of its name. It quickly became the foremost and most destructive tobacco disease of the State and caused great loss and concern among the growers. After its peak in the early twenties, however, it began gradually to decline in severity and distribution with each succeeding year, until, in 1933, it was reported on only four farms. Finally, in 1934, it was found only on one farm in the whole Valley. The widespread use of preventive measures must have had some influence but could not alone account for the disappearance of a virulent disease from a whole territory. It is not in accord with what we know about the history of other diseases of this type. This same fate has also overtaken wildfire in other tobacco sections, notably in Wisconsin. In other states, however, notably Pennsylvania and Maryland, it has become more prevalent each year.

An explanation of its waning course here is a matter of conjecture. Possibly the organism is gradually losing its virulence; possibly the weather conditions during a succession of years have been so unfavorable to its maintenance and spread that the amount of inoculum has been greatly reduced. It is to be hoped that it has disappeared permanently, but there is no assurance that it may not break out again at any time.

ANGULAR LEAFSPOT OR BLACKFIRE

This spot is found only occasionally in Connecticut and has never caused serious loss. Farther south, especially in Virginia, the Carolinas and Kentucky, it has been a serious disease for many years and has received attention of pathologists in those states. No special study of this disease has been made in Connecticut because it is so rarely found.

Angular leafspot is produced by parasitic bacteria (*Bacterium angulatum*) which attack the plants in the seed beds and in the rapidly growing stages in the field. Larger spots, occurring on fully grown leaves in the field, have received the name of blackfire. There is some difference of opinion among plant pathologists as to the identity of these two diseases. Dr. Valteau of Kentucky, who has studied them for many years, restricts the name blackfire to the later spots found on mature leaves. He considers them to be of physiological origin, while angular leafspot, the earlier disease, is of bacterial origin.

The spot differs in appearance from the wildfire spot in being usually angular in outline instead of round, and in lacking the *broad, definitely margined* halo. When there is any yellow around the spots, it runs off irregularly into the green and has no smoothly defined, outer margin. Another characteristic of blackfire is that the spots usually show several shades of brown, from tan to black, in the same spot. The accompanying photograph (Figure 3) shows a leaf of Broadleaf from one of a few infected fields which the writer saw in August of 1934.

RINGSPOT

Ringspot is a minor disease of tobacco leaves that occurs sparingly in Connecticut every year. It has not received much attention here because

the damage, in the aggregate, is small, and the symptoms are usually so inconspicuous that they may easily be overlooked.

This disease has been found on tobacco in all of the important tobacco growing regions of the United States and has been reported from a number of foreign countries. It appears to be much more prevalent in states to the

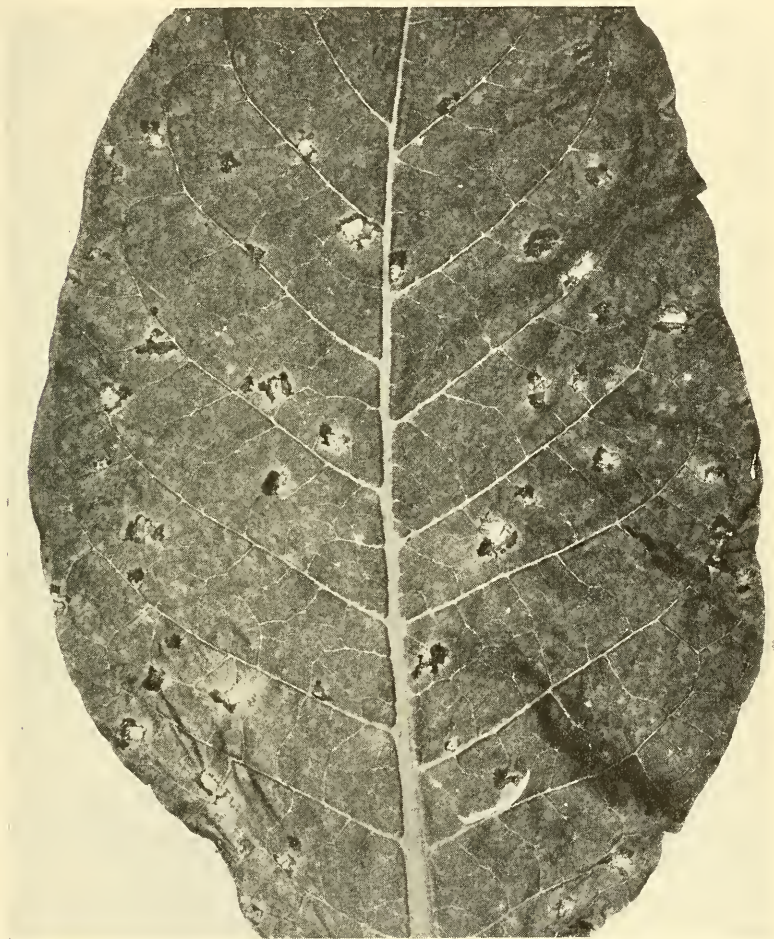


FIGURE 3. Angular leafspot. Note irregular angular outlines of spots and difference in colors.

south. For example, a survey of one county in Virginia* in 1929 showed that it was present in 95 per cent of the acreage. In some fields, 90 per cent of the plants were affected, although the average infection for the county was estimated at 8 per cent. In Connecticut no actual survey has been

*Further Studies on Tobacco Ringspot in Virginia. R. G. Henderson and S. A. Wingard. Jour. Agr. Res. 43: 191-206. 1931.

made but, judging from casual observation, the infection must be less than one per cent.

Ringspot is not a new disease in Connecticut, but there are no definite published records to show how long it has been here. The writer has observed it in small amount every year since he came to this Station in 1925. In Virginia it has been known at least since 1917. It may well have been here long before that time but was overlooked, or not considered of sufficient importance to warrant any published notice. Since leaves with this disease are occasionally brought to the Station for identification or information, it has seemed worth while to summarize here our present knowledge of the cause and symptoms of ringspot and include a photograph which should make the disease easy to identify.

Symptoms. The characteristic symptom of ringspot is the occurrence on the upper side of the leaves of irregular white, or light brown, lines about the width of pencil lines. The lines are more or less continuous but broken lines are not uncommon. The pattern formed by the lines is variable. Between the veins they generally form definite closed circles, or rings, which give the disease its name. The tissue enclosed by the circular lines retains, at first at least, its normal green color. In later stages, it may fade to yellow and finally die. Circles within circles are also common. Along the lateral veins, the lines usually run parallel to the veins and quite close on either side with a tendency to run out to points where secondary branches of these veins run out. Sometimes the lines are not continuous but broken into short segments, or zigzags, scattered without any definite pattern over the leaf surface. Usually the leaf remains flat, but sometimes, especially in the case of the broken line type, the leaf is rough and puckered and with ageing becomes broken and ragged.

Some plants show the symptoms on all leaves from top to bottom. More generally, some of the leaves are affected while the others appear entirely normal. Sometimes only a part of a leaf is affected. The lines may be so distinct that they can be seen for a considerable distance, or so indistinct that they would be overlooked unless one made a close examination.

The symptoms are usually observed first when the plants are nearly or quite mature, but in Virginia they have been found on young plants in the seed bed.*

Severely affected leaves are rendered quite useless. Loss from mild attacks are probably slight or negligible. Stunting of the plants, as found in other tobacco sections, has not been observed here.

Cause. Ringspot is not caused by any parasitic organism or by insects. Neither is there any convincing evidence that it has any relation to the nutrition of the plant, although malnutrition has been suggested by some investigators as a causal agency. Like the mosaic disease, it appears to be caused by a virus, but the two diseases have no other relation to each other. The virus is in the sap of the plant and the disease can be transmitted by transferring the juice of an infected plant to a healthy one. Thus it is an infectious disease. Infected juice on the hands of workmen or on tools may spread it from plant to plant in the field. Possibly insects or other agents may spread it in the same way but there is no experimental

*Citation above from Henderson and Wingard.

evidence on this point. It does not spread so readily as mosaic, however. If the infective capacity were not so low, the number of infected plants would be much larger. The virus of ringspot, unlike that of mosaic, is

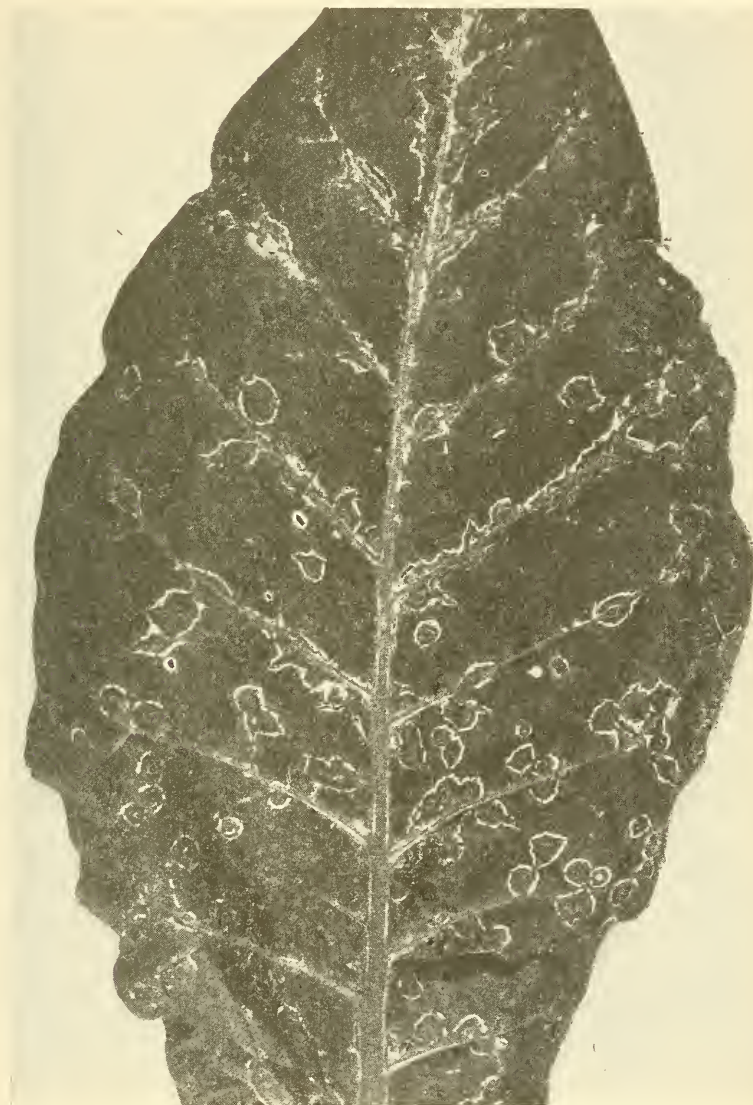


FIGURE 4. Ringspot. Continuous lines follow the veins or form rings between them.

quickly destroyed when the leaves are dried in curing. Hence there is no danger of carrying it to the new crop from the cured leaves of the previous season. Neither is it known to be transmitted through the seed.

Since no tobacco plants remain alive over winter in this climate, and all the virus must die out every winter, it is difficult to explain how the disease gets into the fields every year.



FIGURE 5. Red "rust" following mosaic. Irregular, dead, brown spots run together killing large patches of the leaf.

Wingard* found that ringspot could be transmitted to a large number of species of other plants of 38 different genera in 15 families. It has also

*Wingard, S. A. *Hosts and Symptoms of Ringspot, a Virus Disease of Plants.* Jour. Agr. Res. 37: 127-153. 1928.

been found occurring naturally on some of these plants in the field. Many of these are common weeds and garden plants. Since some live over the winter, he suggested the possibility that they might serve as agents for



FIGURE 6. White fleck following mosaic. The numerous little white specks that pepper the leaf are not round, but irregular in outline.

keeping the virus alive until the next season. It is quite possible that there are weed plants around our tobacco fields and beds here which may serve as winter hosts and thus account for primary infection in the spring.

There is no known method of controlling ringspot.

MOSAIC "RUST", OR FLECK

Plant pathologists restrict the use of the term "rust" to diseases of plants produced by parasitic fungi of one certain group, the Uredinales. Since no fungus of this order occurs on tobacco, we cannot say that we have a true rust of tobacco according to the pathologists' definition. However, tobacco growers for generations have applied the name "rust" to leaf spots of tobacco which appear suddenly on nearly mature tobacco in the field. The term is rather loosely used, some growers applying it to all leaf spots, others to only one type of spot. Some distinguish between a "red rust" and a "white rust" of tobacco. Probably the term is used most often to apply to the types of spot which accompany the mosaic disease (calico, brindle and gray top are other names of the same disease).

Rust or other types of leaf spots, however, are by no means always present on plants affected by mosaic. Many severely affected plants never show any dead spots. Yet it is not unusual for the leaves of mosaic plants, especially just before harvest, to develop dead areas of various sizes, shapes and colors. In the most usual form, areas of irregular shape and size, (Figure 5) especially on the top leaves, die and turn rusty brown. Sometimes the dead spots are several inches broad and may kill most of the leaf surface by running together. Often, however, the spots are small and scattered. In the "fleck" type (Figure 6) they are quite small—one-eighth to one-fourth inch across—very numerous on the leaf and are white instead of brown. There may be all gradations between these types. None of them, however, are predominantly round; neither do they have a definite yellow halo.

If there is any uncertainty as to the identity of the mosaic spots, one must look first for the other signs of mosaic on spotted or other leaves of the plant. Some of the leaves will show the alternating mottling of yellowish and green areas on the distorted leaves. It has been explained that the weakening of the chlorophyll makes the leaves less able to withstand the heat of the sun and the rust spots represent tissue killed by the sun's rays. This may be partly true but could hardly explain the occurrence of rust spots, particularly the "fleck" type, on the lower, shaded leaves.

THE JOHN WILLIAMS BROADLEAF SPOT

This, the most common of all physiological spots on Connecticut tobacco, is not regarded by the growers as a damaging disease. It becomes most pronounced when the leaves are mature and therefore buyers learned long ago that a generous speckling of the leaves was an indication of ripeness and hence of better quality. Instead of discriminating against such crops, they rather favored them. Such preference led to the peculiar custom, early in the present century, of sprinkling the leaves in the field with acids, ammonia or other chemicals, to produce artificially dead spots similar to the John Williams spot. For a period of years, cigars with spotted wrappers were much in vogue.

Among the several varieties of Broadleaf tobacco, the John Williams is perhaps the most popular with dealers and manufacturers. The John Williams type of spot is almost peculiar to this variety. Most crops of other varieties, such as Hockanum, are usually quite free from it. In

fact, the presence of this spot came to be recognized as a character by which the John Williams variety could be identified.

In the course of a field survey during 1934, the writer sometimes found the disease on crops which the grower stated were not of the John Williams variety. However, since this variety has frequently been hybridized with others, identification is difficult. Most of our Broadleaf varieties are quite similar in appearance and few men are experienced enough to claim that they can certainly identify them. This confusion makes it difficult even to estimate to what extent the John Williams spot appears on other kinds

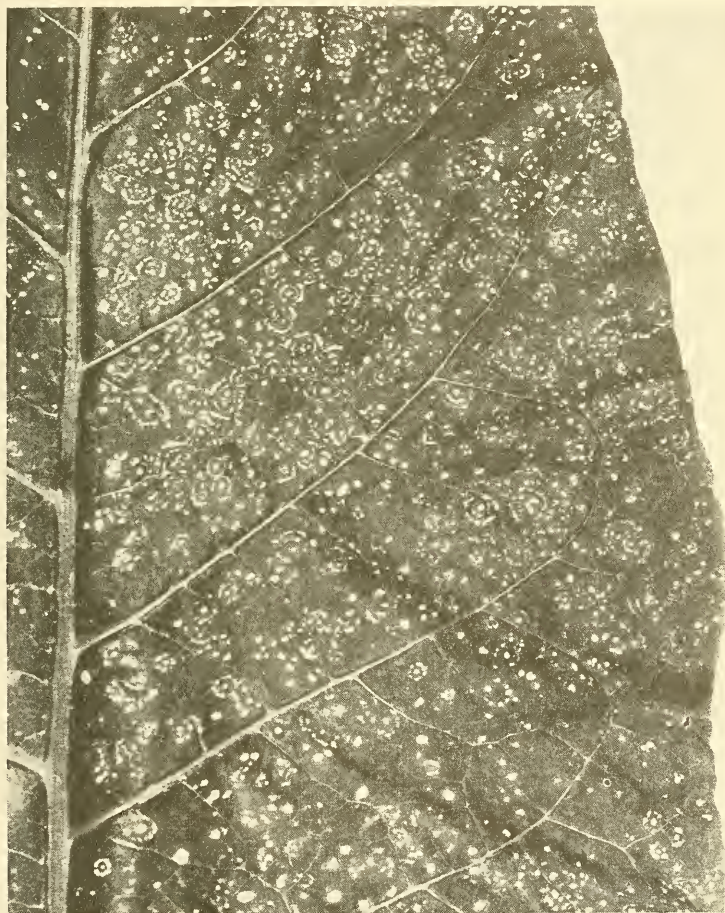


FIGURE 7. John Williams Broadleaf spot. Arrangement of the spots in rings is common but not always present.

of Broadleaf. At least we may say that it is decidedly more common on the John Williams variety. The writer has never seen any spots similar to it on Havana Seed or Shade tobacco. A number of years ago, he found a severe case of what appeared to be the same disease on a Mongrel

variety which was a cross between Havana Seed and Broadleaf. Probably the Broadleaf parent of this type was of the John Williams variety.

Symptoms. Characteristically, the leaves just before harvest become speckled with numerous, small, white spots. The spots usually appear suddenly in great numbers just after topping, but, contrary to popular opinion, they may be found in smaller numbers at earlier stages when the plants are much younger—even before the buds appear. They are more numerous on the lower than on the top leaves but may be found on all leaves. Although typically a leaf is well spotted, the number of spots ranges from a half dozen to a thousand.

They are always small, rarely over one-eighth inch in diameter and usually less, down to the size of mere pin pricks. In outline the single spots are roundish or irregular, but rarely exactly round. Bars and irregular shapes of various descriptions are produced by coalescence of spots. They are always between the veins; otherwise their position shows no relation to the veins or location on the leaf. Sometimes they are clustered more densely toward the tip, sometimes at the heel or the margin. The tissue in the spots is dead, thin, papery and visible on both surfaces of the leaf. Unlike most of the other spots on the leaves, the affected tissue keeps its white color permanently. Also there is no yellowing or blanching of the green tissue immediately adjacent to the spots.

A peculiarity frequently but not always exhibited is the arrangement of the spots in rings. Usually there is a single spot at the center surrounded, or partly surrounded, by one or more regular circles of spots. These circles may be only partly complete. Also, it is a common occurrence for the spots to be so close that they run together forming bars, or solid segments, of the circle. The tissue between the circles usually keeps its normal green color, but in severe cases parts of it may die. The diameter of the circle ranges from one-quarter inch to one inch.

In very severe cases larger areas of the leaf may die. The lower leaves, especially in dry weather and when harvesting is delayed, may dry out and be lost. This latter condition, however, is not common.

Cause. The writer has never been able to find any fungi or bacteria in the John Williams spots which might be causal agents. Neither has any insect been found associated with this condition. Also there is no indication that this is a virus disease, although sufficient investigation of this possibility has not been made. It is more likely that the spot is a physiological breakdown of the tissues which causes these as well as numerous other types of leaf spots found on tobacco from all parts of the world.

It is not apparent why this kind of spot should be so nearly confined to the John Williams type of tobacco. Any one disease, however, is often found to exhibit different and peculiar symptoms on different species of plants. The same principle may also apply here to different varieties of the same species.

BROWN LEAF SPOT AND WHITE SPECK

“Brown leaf spot” and “white speck” are popular names applied to two symptoms of what appears to be the same disease. It is not a leaf spot of major importance from the standpoint of total loss occasioned, but it

affects some fields every year and appears on all three types of tobacco. The symptoms described below make it rather easy to distinguish from all the other kinds of spots which occur on tobacco in Connecticut.

Similar spots have been described on tobacco leaves from many tobacco growing regions of the world so that it seems probable that it is cosmopolitan. The occurrence, however, of so many different kinds of spots on tobacco leaves, and the lack of specific detail in most descriptions, make it difficult to be sure that the various writers had under observation the same disease as the one we are considering.

In Connecticut brown leaf spot is of long standing. In the annual report of the Experiment Station for 1898, page 254, Sturgis describes a disease of tobacco leaves which was:



FIGURE 8. Brown spot. This enlarged photograph shows the concentric rings typical of this disease.

“signalized by the presence of small circular spots . . . at first yellowish in color and somewhat irregular in outline. Later they take on a circular form and become marked off from the surrounding tissue by a narrow border of darker color. . . . The tissue within this border finally dies and becomes almost white but except in very severe cases, it does not break away from the leaf. . . . Scores of spots have been microscopically examined during the past three years without showing any evidence of the presence of fungi, insects or bacteria.”

Again in the report for 1903, page 363, Clinton writes:

“The writer has found, in tobacco grown under cloth, circular brown spots about one-quarter of an inch in diameter on the leaves . . . had the

appearance of the spot produced by the *Alternaria* fungus on potato, had the same faint concentric rings of development, but no signs of any fungus were discovered."

Both Sturgis and Clinton apparently were watching this same spot which the writer has observed in greater or less degree every season for the last 15 years.

Symptoms of brown spot. The spots are deep, chestnut brown, usually of somewhat lighter shade at the center. Older, larger spots show definite zonation, or target board effect, produced by darker concentric circles (Figure 8). In smaller spots such circles are not present. The spots are quite definitely round in outline and in this respect differ from many of the other tobacco leaf spots. The margin is sharp and dark. The surrounding tissue of the leaf retains its normal green color except in old, mature leaves, where it may gradually fade to yellow, but there is no decided halo. In size, the spots vary from an eighth to a quarter of an inch across. The spots on Shade tobacco are smaller than those on the other types. They are visible on both surfaces of the leaf and are usually not thickly clustered but scattered irregularly. They do not fall out in curing but become somewhat lighter in color.

Brown spot differs from the red rust spotting which follows mosaic in its regular round outline. Red rust spots are of irregular shape and tend to run together into extensive dead blotches. The presence of yellow mottling in the green leaf, accompanying red rust, is, of course, the most certain diagnostic difference. Brown spot differs from the wildfire spot in lacking the yellow halo. Sometimes in dry weather, however, this halo disappears and then there may be some confusion. But examination of a sufficient number of lesions will show that some of the younger spots of wildfire exhibit the characteristic halo. The shape of the brown leaf spot easily distinguishes it from John Williams Broadleaf spot and from angular leaf spot. Its size and color also differ from those of the John Williams spot.

White spot or white speck. Similar spots which are white instead of brown also occur on the leaves. This condition has received the popular name of "white spot", or "white speck", and has been considered a different disease from brown spot. Brown spots and white spots, however, are very commonly (but not always) intermingled on the same plant.

On plants which are predominantly brown spotted, one usually finds some white spots, and vice versa. Yet they do not represent two different developmental stages of the same disease. Observation for a month at a time on the same plants in 1934 convinced the writer that white spots always remain white. Brown spots remain brown usually but may become lighter in shade with age. Also they do not increase in size after they are once developed. They appear on the leaves with magic rapidity and the writer has failed to find any intermediate stages of development. They probably represent two different manifestations of the same causal agency and there seems to be no adequate reason for regarding them as two different diseases. Why, in the breakdown of the tissue, some should become white and others brown is not obvious.

The Fungus *Alternaria* on the White Spots

The brown spots are very similar in appearance to numerous other familiar spots on a variety of plants which are known to be produced by parasitic fungi. The concentric dark rings sometimes found on these brown spots of tobacco suggest at once the spots produced by *Alternaria* on potato, tomato and other plants. No spores of this or any other fungus, however, could be found on the surface of such spots. The writer has also made frequent microscopic examinations of the dead tissue of

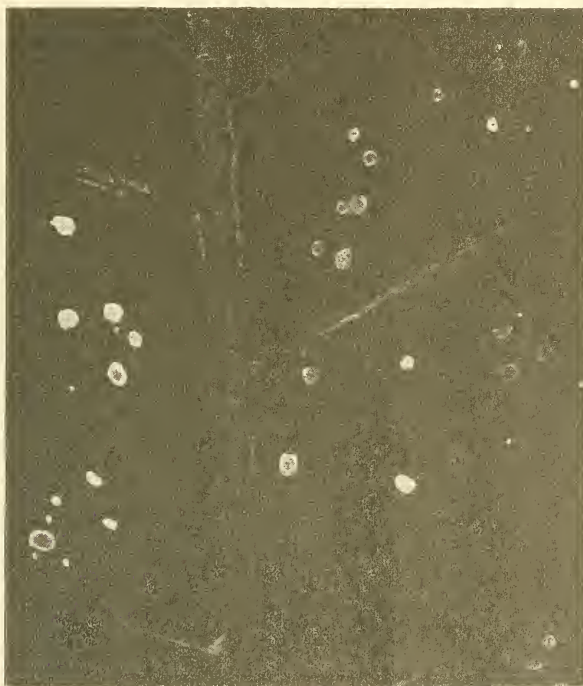


FIGURE 9. White spot. (Somewhat enlarged). The darker centers on some of the spots are due to growth of *Alternaria*.

these brown spots both by teasing the tissues apart and by free hand and microtome serial sections. No fungous mycelium, however, could be found. Attempts to isolate a fungus by culture methods have also failed. The occasional appearance of an *Alternaria* and of some other fungi on the culture plates was interpreted as accidental, due to contamination or the presence of spores that had fallen on the surface of the leaf. These failures to find consistently any fungi, coupled with the similar experiences of Sturgis and Clinton, lead the writer to doubt that the brown spots are produced by fungi or bacteria.

Experience with the white spots, however, has not been the same. At various times, both in the field and on leaves kept in the laboratory or greenhouse, it has been observed that some of the white spots have darker centers, varying in intensity from gray to almost black (Figure 9).

Microscopic examination of such centers shows that the darker color is due to the presence of spores and sporophores of a fungus of the genus *Alternaria*. This fungus does not appear on all the spots. Many spotted leaves have been kept under moist conditions for weeks at a time without showing any fungus. It is easily isolated in pure culture where it grows and sporulates on a wide range of culture media. It has been studied both in culture and from leaves taken from the field. The following description of the fungus is from spots as they occur in the field.

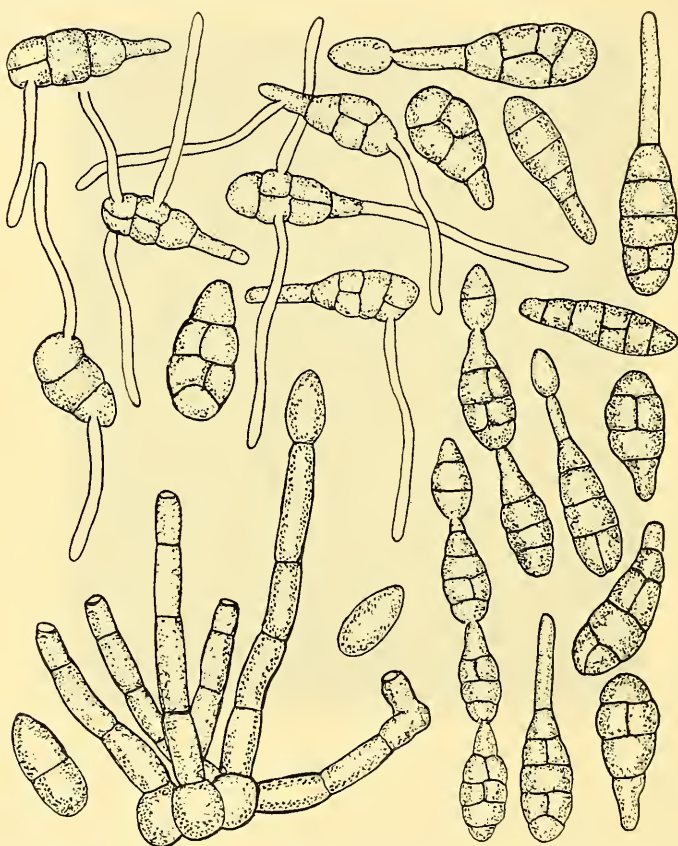


FIGURE 10. Spores and sporophores of the fungus (*Alternaria*) from white spot. Tuft of sporophores with one young spore attached shown in lower left. Germinating spores in upper left. Chains of spores and single spores on the right.

Description of *Alternaria*. (See Figure 10) The spores are dark olive color (black in mass) as seen under the microscope. They are ovate to obclavate in shape, the larger ones being drawn out into a longer or shorter beak which is lighter in color. Smaller and younger spores have no beaks. All but the smallest (youngest) are muriform, with one to five cross septa and one to three of the cells divided again by longitudinal septa. The spores are somewhat constricted at the septa, the

depth of constriction increasing with the maturity of the spore. They measure 30 to 65 microns long by 9 to 17 microns wide, averaging about 45 by 12 microns. The beak, when present, is 4 to 25 microns long (averaging 12 microns) and usually not septate. The wide variation observed in size, shape and septation of spores and beak cells (Figure 10) is due both to stage of maturity and to the conditions under which they are produced. In culture on various media, the spores are somewhat smaller and show more extreme variation in shape, septation and beak characters. On the leaves, the spores are often found to be attached end to end, two or three in a chain; in cultures, the writer has found six or eight of them still attached.

The spores, or chains, are borne on the tips of stout, dark, olivaceous sporophores which arise singly or more often in tufts of two to six from the leaf surface. Frequently these sporophores emerge from the stomata but I am not certain that this is always the case. The sporophores are septate, with two to five cross walls, straight or more often crooked, usually simple but occasionally forked once, and each arises from a somewhat enlarged basal cell.

The hyphae inside the tissues of the dead spots vary greatly in diameter. The largest is about the same as the sporophores, the smallest, only about one-fourth as stout. For the most part, the submerged mycelium is hyaline, only the oldest hyphae becoming olivaceous. Septa are not very distinct in the youngest hyphae but become more pronounced as the hyphae become older. The hyphae are very abundant in the dead tissue and appear to be between, rather than inside, the cells; but in the collapsed condition of all the tissues, it is difficult to be sure that they are always outside the cells.

Specific identity of the fungus. The association of species of *Alternaria* with leaf spots and other disorders of tobacco has been observed by previous investigators.

In 1892, Ellis and Everhart* described two species of *Macrosporium*† on tobacco in North Carolina. One of these, *M. tabacinum*, occurred on, and was apparently assumed to be the cause of, the white speck on the leaves, a disease which appears to be identical with our white spot in Connecticut. They describe the spores as follows:

"Conidia obovate, 15 to 25 by 10 to 12 microns, sessile, or longer (35 to 45 microns), narrowed below into a distinct stipe, 8 to 12 microns long. The shorter conidia are mostly 3-septate and the longer ones about 5-septate, one or two of the cells with a longitudinal septum".

The "stipe", which they mention, is the beak cell of our description above. The spores, as described by them, do not differ in any respect from these which we have found here. The characters of the spots on the leaves which they found in North Carolina are the same as for the spots in Connecticut. There is no reason to doubt that both the disease and the fungus are the same in the two states.

The second *Macrosporium* described by them, *M. longipes*, occurred on the brown spots of tobacco and had much larger spores. They give the dimensions as 40 to 50 by 15 to 20 microns but also with an equally long

*Journ. Myc. 7: 134. 1892.

†Many species of *Alternaria* were originally described as *Macrosporium*, a genus which differs from *Alternaria* mainly in having the spores borne singly instead of in chains.

"stipe" of 35 to 50 microns, thus making the entire length of the spore (including stipe) up to 100 microns. Since spores of more than about 65 microns have never been found here on either white or brown spots, it seems certain that our fungus cannot be *Macrosporium longipes*.

In 1931, Tisdale and Wadkins* described a brown spot of tobacco from Florida which they found to be associated with a species of *Alternaria* and which they were able to produce by inoculation with this same species. They decided that this fungus was identical with the *Macrosporium longipes* described by Ellis and Everhart, although there was some discrepancy in spore size. They referred the fungus to the genus *Alternaria* where it rightfully belongs. The fungus, as described and pictured by them, in dimensions and in all other characters, appears to be the same as we have found here on the white spot.

In the same year Ghimpu† described a disease of tobacco in Rumania characterized by large brown spots on which were found *Alternaria* spores. He referred this to *Alternaria tenuis* Nees. He also found the ascospore stage, *Pleospora Alternariae* Gib. and Griff., in the dead leaves. His description of the spores, which he found to be 25 to 50 microns (maximum 68 microns) in length, and 10 to 15 microns in diameter, agrees in every particular with our own, as given above. Morphologically the two seem to be identical.

In Connecticut, we have found what appears to be this same species of *Alternaria* on leaves affected with disorders other than the spots we are now considering. On the rust spots which follow mosaic, and on the John Williams Broadleaf spots under moist conditions, one sometimes finds *Alternaria* spores in abundance. In an investigation of the fungi associated with stem rot (a rot of the midrib of the leaf during curing) and pole sweat, in which the writer has been engaged during the last year, he has found what appears to be this same species more often than any other fungus. Johnson in Wisconsin finds *Alternaria tenuis* associated with pole sweat and considers it the causal agent of that disorder.

There do not, then, appear to be any significant morphological differences among *Macrosporium tabacinum* of Ellis and Everhart, *Alternaria longipes* of Tisdale and Wadkins, *Pleospora Alternariae* of Ghimpu and the fungus which the writer has found associated with the spots and other disorders mentioned above. In the absence of other bases of distinction between species of *Alternaria*, they may all be referred to *Alternaria tenuis* Nees (*Pleospora Alternariae* Gib. and Griff. if one prefers the name of the perfect stage) or, at least, to the *Alternaria tenuis* group, as arranged by Elliott.‡

Is *Alternaria* the causal agent of "white spot"? After isolating and growing the fungus in pure culture, inoculations were made with it on mature plants of Havana Seed and of Broadleaf in the greenhouse in September. Some of the leaves were sprinkled with a suspension of spores in water; some of the leaves had drops of the same water placed on them from a medicine dropper; on other leaves bits of mycelium and blocks

*Tisdale, W. B. and R. F. Wadkins. Brown spot of tobacco caused by *Alternaria longipes* (E & E) n. comb. *Phytopath* 21: 641, 1931.

†Ghimpu, V. La maladie des tabac causee par *Pleospora Alternariae*. *Bul. Cult. si ferment. Tutunului* 20 No. 1: 1-27, 1931.

‡Elliott, John A. Taxonomic characters of the genera *Alternaria* and *Macrosporium*. *Am. Jour. of Bot.* 4: 439-477, 1917.

of agar containing mycelium were laid and kept moist for several days until there was a luxuriant growth of aerial mycelium. Leaves of all ages were inoculated. All the plants were kept under a glass chamber for five days during which time the air was so saturated that the drops of water on the leaves did not evaporate. Some of the leaves were punctured repeatedly by a sterile needle. With the exception of some of the most mature leaves which had been punctured, no sign of infection occurred. On the old leaves, a thin margin of dead tissue appeared around the punctures. In some cases where the punctures were close together, the intervening tissue died after three or four weeks. Even then the spots did not have the appearance of the spots in the field. It was apparent that under these conditions the fungus is not parasitic or at most has an extremely low degree of parasitism. The sudden, widespread and rapid development of the spots as they come on in the field could not be caused by such a weak parasite.

A more convincing argument against the causal agency of this fungus is the fact that it cannot be found at all in a large proportion of the spots in the field. Not only do spores fail to appear on many of the spots, but repeated cultural attempts have failed to isolate any fungus. Moreover the most thoroughgoing microscopical investigations of fixed and stained microtome sections, as well as free-hand sections and teased tissues, have failed to show any trace of mycelium.

The fungus, then, can only be regarded as a fortuitous saprophyte which lives on the tissues of some of the spots after they have died from some other cause. Neither are any bacteria to be found in these spots. The breakdown and collapse of the cells which may be seen under the microscope must be due to some abnormal physiological condition, or unbalanced chemical state in these restricted areas.

TOBACCO INSECTS IN 1934

Donald S. Lacroix

PREVALENCE OF VARIOUS SPECIES

The severe winter during the early part of the season of 1934 seemed to have little influence upon insect abundance later in the year. Most species attacking tobacco were present in their usual numbers, the only exception to this being the tobacco thrips, *Frankliniella fusca* Hinds. This pest was not so serious as in 1933 but appeared on one or two plantations in numbers large enough to do damage of commercial importance.

Wireworms, *Pheletes ectypus* Say, in particular, were present, but many plantations that suffered from their injury in 1933 had few or none in 1934.

The potato flea beetle, *Epitrix cucumeris* Harris, was fully as injurious to Havana Seed tobacco as in 1933. No specimens of the southern tobacco flea beetle, *Epitrix parvula* Fabr., were seen.

Hornworms, both *Phlegethontius quinquemaculata* Haw., and *P. sexta* Johan., were present in the Connecticut Valley. Possibly they were less numerous than they were last year. A severe infestation developed in

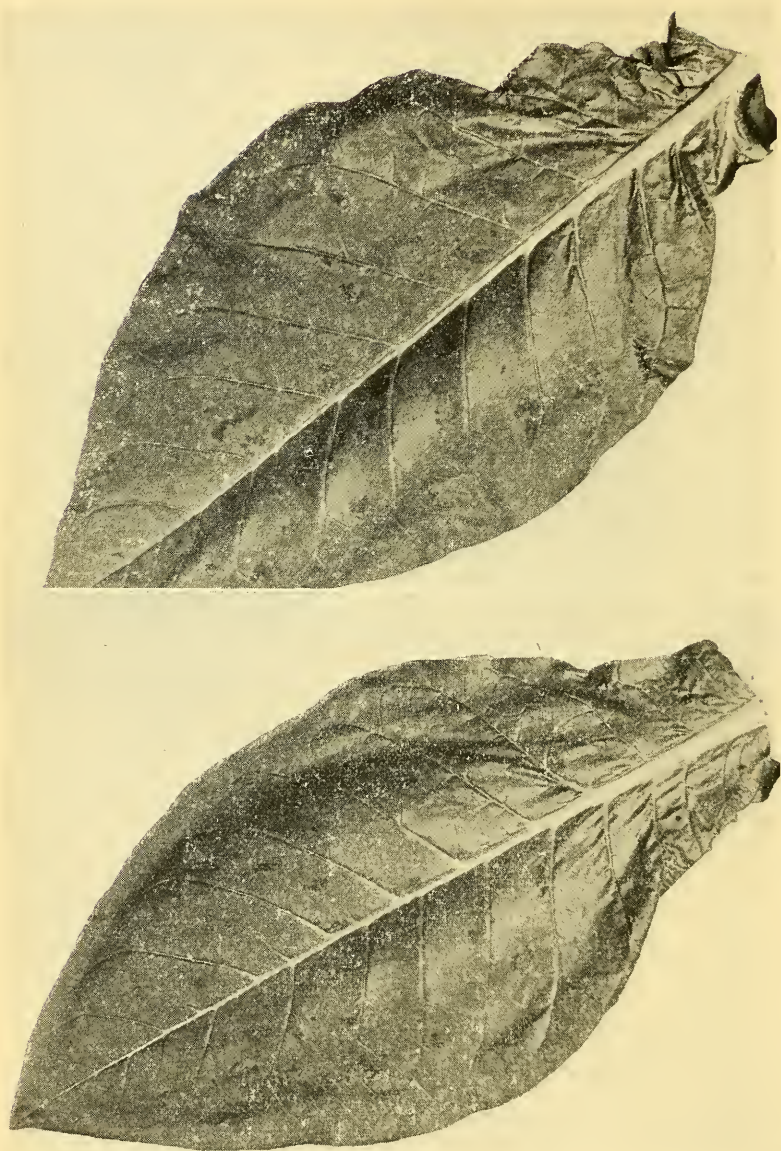


FIGURE 11. The illustration (left) shows a leaf dusted with barium fluosilicate to control flea beetles; the leaf (right) was not dusted. Note the flea beetle holes around the margin of the undusted leaf.

Manchester in which the northern species (*P. quinquemaculata*) outnumbered the southern by two to one.

Grasshoppers were unusually abundant around Windsor, particularly the Carolina grasshopper, *Dissosteira carolina* Linn. In Burnside, East Hartford and Manchester, the red-legged grasshopper, *Melanoplus femurrubrum*, DeG., outnumbered all other species.

The spined stink-bug (*Euschistus variolarius* Beauv.) was taken in small numbers on sun grown tobacco.

Only an occasional specimen of the tarnished plant bug, *Lygus pratensis* Linn., was observed.

Very few of the first brood of the Southern Tobacco Bud worm (*Heliothis virescens* Fabr.) were seen. In August, however, several second-brood larvae were taken in Windsor, East Hartford, West Suffield and Granby, indicating that the insect is extending its range, although the total population seems to remain at a very low figure.

Cutworms of various species were taken throughout the season. A very early and destructive (May 5, 1934) infestation appeared in West Suffield in seed beds. The larvae were migrating from dead weeds and hayland into the beds. In one series of beds almost every plant was devoured and the beds totally ruined. The species involved was the "well-marked" cutworm *Noctua clandestina* Harris. Frequent reports from other localities indicated that seed bed injury by cutworms was general this year.

The spotted cutworm (*Agrotis c-nigrum* Linn.) was found causing severe injury to the outside rows of some Broadleaf tobacco in Granby on July 17, 1934. In this case the larvae (nearly full grown) were migrating from an adjoining alfalfa field.

The seed corn maggot, *Hylemyia cilicura* Rond., caused considerable injury in and around Windsor during the last week in May, one plantation having to be entirely reset.

No specimens of the stalk borer, *Papaipema nitela* Guen., were found or reported.

FLEA BEETLE CONTROL

Barium fluosilicate has been used very successfully during the last few seasons as a control for the potato flea beetle on tobacco. From time to time, reports reach us to the effect that poor control has resulted from its use, and in each case the user has indicated that the material was applied at the recommended rate of six pounds to the acre. Experiments and actual applications on a commercial scale have proved that six pounds to the acre will do the work on normal infestations, on plants half to two-thirds grown.

Heavy infestations of the beetle and full grown plants (particularly the Havana Seed and Broadleaf) quite naturally require larger doses and in some cases more frequent applications. Amounts up to 12 pounds of barium fluosilicate may be used on full grown plants without leaving visible residue. (Figure 11 shows photographs of Havana Seed leaves from dusted and untreated areas at the Experiment Station).

A Comparison of the Effectiveness of Several Insecticides for Flea Beetle Control

Dusts containing pyrethrum and rotenone are being applied widely on many plants, especially those which are to be used for human consumption.

These two materials are not toxic to warm blooded animals, but are toxic to many insects. It has been known for some time that they will kill the potato flea beetle. It has also been known that they lose some of their toxic effect on prolonged exposure to atmospheric conditions.

During the summer of 1934, pyrethrum dust (fine ground flowers), rotenone dust (one-half per cent) and barium fluosilicate were used side by side on Havana Seed tobacco on the Experiment Station plots. On July 9, one application of each dust was made, barium fluosilicate at the rate of six pounds to the acre, pyrethrum, eight pounds and rotenone, eight pounds. Twenty-four hours later, population counts (see Table 7) on these plots and untreated check plots showed that the pyrethrum and rotenone dusts had killed many flea beetles, and that barium fluosilicate had reduced the beetle population without leaving much evidence of dead individuals.

TABLE 7. COMPARISON OF INSECTICIDE DUSTS AGAINST FLEA BEETLES.

	July 11, 1934		July 16, 1934		July 20, 1934	
	Dead	Alive	Dead	Alive	Dead	Alive
Cubor	12	16		97		228
Check		59		151		192
Dutox and Tobacco Dust	1	41		41		56
1 to 3						
Check		97		207		199
Pyrethrum	7	12		72		107
Check		56		188		171

Because of the fact that there was no rainfall at Windsor from July 9 to July 26, only one application of these materials was made. Population counts were continued, however, and it can be seen from an examination of Table 7 that the flea beetles soon became very numerous on the plots treated with pyrethrum dust and with rotenone dust, but did not reestablish a large population on the plot dusted with barium fluosilicate.

Still another comparison was made, in this case between rotenone dust (one-half per cent) and barium fluosilicate. (These two materials are being widely advertised and sold in the Connecticut Valley). The Experiment Station plots were treated with these materials on July 12, a little less than one-half of each field receiving barium fluosilicate (6 pounds to the acre) and a little less than one-half receiving rotenone dust (one-half per cent) at a rate of about 10 pounds to the acre. The rest of each field was used as a check on these treatments. Table 8 presents the beetle population on these fields. (Havana Seed tobacco in each case). By July 23, the beetles were causing such injury to the plots dusted with rotenone that the half first treated with this substance was dusted with barium fluosilicate.

To sum up these comparisons made in the two tests recorded above, it is evident that pyrethrum and rotenone are both toxic to the potato flea beetle, but it is also evident that their potency is lost within a few days after exposure to the atmosphere. Barium fluosilicate does not show its toxicity to flea beetles immediately, but it keeps the beetle population down

TABLE 8. COMPARISON OF INSECTICIDES FOR FLEA BEETLE CONTROL, WINDSOR, 1934.

Material	Flea beetle population on 25 plants								
	Field I			Field V			Lime field		
	July 18	July 23	July 27	July 18	July 23	July 27	July 18	July 23	July 27
Barium fluosilicate	20	36	71	29	53	93	33	47	81
Rotenone (1/2%)	61	137	*42	34	169	*29	42	107	*39
Check	137	179	264	121	186	243	143	155	161

*All Rotenone plots dusted with Barium Fluosilicate on July 24, 1934.

to a low figure over an extended period of time if it is not washed off by rains. The irritating action of this material keeps the beetles off the foliage, and a careful examination of the ground around plants treated with barium fluosilicate will bring to light many dead beetles.

These tests indicate that during a rainy season, in which several applications of dust are necessary, any of the three dusts would undoubtedly give good control.

TOBACCO THRIPS CONTROL

In 1933, infestations of the tobacco thrips, *Frankliniella fusca* Hinds, reached such proportions that various dusts and sprays were tried to find an efficient control (see Tobacco Substation Report for 1933). Sprays gave better control in every case, but as most shade tobacco growers are equipped to use dusts, and since a spraying apparatus for use on tobacco is out of the question, an efficient dust would be more acceptable.

Steps were taken in 1934 to find a dust which would be fine enough in texture to go between the hairs on the surface of the tobacco foliage. Microscopic examinations of several types of dust and inert carriers indicated that such a material could be found.

However, the thrips infestation at the Experiment Station was so small that no accurate figures could be obtained. Work on this phase of control will be continued as soon as possible.

TOBACCO HORNWORM CONTROL

An opportunity was presented early in July to determine the effects of barium fluosilicate dust and lead arsenate dust for the control of hornworms (green worms) on tobacco. Both the northern and the southern species were involved on nine acres of Broadleaf tobacco. Half the plantation was dusted with barium fluosilicate and half with arsenate of lead, each at a rate of six pounds to the acre, on July 9, 1934. A second application was made 10 days later. After the first application, dead and dying worms were readily found, and the second dusting completed the control except for worms two-thirds or more grown—these apparently were not affected by either of the materials used. As far as our observations went, there was no difference in the efficiency of the poisons used. Any attempt to control these pests with insecticides must be started early in July, when the larvae are beginning to hatch, as large amounts of poison are required to kill larvae over half grown.

THE BIOLOGY OF THE EASTERN FIELD WIREWORM* IN TOBACCO SOILS

During the last three years periodic examinations of wireworm infested soils have been made during the spring, summer and fall. The problem of control of this pest may possibly be solved through careful observation of all factors that bring about optimum conditions for wireworm infestation. It is hoped that in due course of time an analysis of all these factors—life history, soil temperature, soil moisture, soil reaction (acidity or alkalinity), *et cetera*—may bring to light some weak point in the biology of this pest, at which a control remedy may be aimed.

A summary of all observations made thus far indicates that adults (known as click beetles) emerge from the pupa stage beneath the soil in late August and early September. They remain below the soil surface (6 to 12 inches) until the following spring when they crawl out. Adults have been taken above ground as early as May 5 in small numbers, and as late as June 2. During the last four years, the peak of emergence above ground has been during the last week in May.

At that time, they may be found flying and also crawling on boards, posts and particularly on the sides of tobacco shade tents. Large numbers of both males and females have been taken from the shade cloth, singly and *in coitu*. Specimens placed in rearing cages deposited eggs in moist soil from May 19 to June 3. The eggs were laid singly and also in groups of three or four. Each egg was glistening white, oval, one-third mm. long and about a third as wide. Eggs hatched in two weeks.

In an attempt to determine the preference of the female for soil moisture, three pans of soil were placed in each of two rearing cages. Each cage contained 100 males and 100 females. One pan of soil in each cage was dry top-soil and had no moisture added during these observations. A second pan of soil was kept moderately moist (about 20 per cent) and a third was kept saturated. These pans were examined twice (May 26, 1934 and June 3, 1934) and the contents noted. (See Table 9).

Adults showed a marked preference for moist soil and a larger number were found in the moderately moist than in the saturated soil.

TABLE 9. WIREWORM PREFERENCE FOR SOILS OF DIFFERENT MOISTURE CONTENT.

	Dry soil	Moist soil	Wet soil
May 26, 1934	3 adults no eggs	17 adults 1 egg	13 adults 10 eggs
June 3, 1934	2 adults no eggs	21 adults 3 larvae newly hatched	13 adults 1 larva newly hatched

Some preliminary tests on the attractiveness of baits to wireworm adults were started in 1934. Bran, rolled oats, rolled wheat and clover leaves were placed just below the surface. A larger number of adults were attracted to the bran than to any of the others.

**Pheltes Ectypus* Say.

To date, it has not been accurately determined just how long larval life continues, but it seems possible that it may require at least three years to complete the life cycle of this insect.

Pupation takes place late in July and early in August, anywhere from 6 to 12 inches below the soil surface, usually between 6 and 9 inches. The pupa is naked, (unprotected by any covering) white, and about half an inch long (see Fig. 137, p. 498 in Tobacco Substation Report for 1932).

TABLE 10. DISTRIBUTION OF WIREWORM LARVAE IN SOIL OF TOBACCO PLANTATION, WINDSOR, CONN., 1934.

Date	Number of larvae in soil				Percent	Soil reaction	Soil moisture
	Depth	In row	Between rows	Total		pH	air dried
May 5	0"—3"	4	0	4	13.7	5.60	17.9%
	3"—6"	10	0	10	34.4	5.84	17.9
	6"—9"	4	9	13	44.8	6.18	17.3
	9"—12"	0	2 (adults)	2	6.8	5.00	17.1
	12"—24"	0	0	0	0.0	5.50	19.3
		18	11	29			
May 19	0"—3"	4	4	8	12.5	5.17	18.2
	3"—6"	10	6	16	25.0	5.00	22.5
	6"—9"	18	18	36	56.2	5.14	21.8
	9"—12"	2	2	4	6.7	4.76	22.8
	12"—24"	0	0	0	0.0	5.00	23.7
		34	30	64			
June 2	0"—3"	3	0	3	10.7	4.49	13.3
	3"—6"	2	3	5	17.8	5.00	15.7
	6"—9"	3	6	9	32.1	4.93	15.4
	9"—12"	6	5	11	38.3	5.24	17.8
	12"—24"	0	0	0	0.0	5.40	13.6
		14	14	28			
June 9	0"—3"	1	1	2	11.1	4.47	8.4
	3"—6"	4	0	4	22.2	4.61	13.9
	6"—9"	2	3	5	27.7	5.29	14.0
	9"—12"	4	3	7	38.8	5.17	14.4
	12"—24"	0	0	0	0.0	5.00	16.6
		11	7	18			
July 9	0"—3"	0	3	3	9.6	5.12	
	3"—6"	2	1	3	9.6	5.20	14.8
	6"—9"	4	3	7	22.5	5.10	13.7
	9"—12"	10	5	15	48.4	4.86	16.8
	12"—24"	2	1	3	9.6	5.00	17.9
		18	13	31			
Aug. 8	0"—3"	0	4 (2pupae)	4	18.1	4.55	8.4
	3"—6"	4	0	4	18.1	5.05	9.6
	6"—9"	6 (2pupae)	4	10	45.4	5.15	11.8
	9"—12"	4 (2pupae)	0	4	18.1	5.00	12.6
	12"—24"	0	0	0	0.0	5.00	10.0
		14	8	22			

It has been observed that the wireworms infesting newly transplanted tobacco were nearly all of the same size. To check this observation more accurately, larvae were taken from infested plants on an East Hartford plantation and measured. Of 1075 wireworms examined, 763 were from 18 to 20 mm. long, 289 were from 13 to 17 mm. long, and 23 were from 8 to 12 mm. long. Similar measurements were made on larvae taken from newly set plants on the Experiment Station plots and of 47 examined, 44 were from 18 to 20 mm. long, and only 3, from 13 to 17 mm. long. All of these were placed in underground cages, segregated as to length, and were examined again in late August. No pupae were found.

No distinct correlation has yet been found between larval population and soil temperature, moisture or reaction, although there seems to be a tendency towards a congregation of larvae at soil levels having a pH of 5.15 to 5.20.



FIGURE 12. Dusting tobacco for control of flea beetles.

Table 10 presents the figures for larval population at several soil horizons examined throughout the season of 1934, along with soil moisture (on air dry basis) and soil reaction (in terms of pH). These observations were made as in former seasons, that is, two areas, each two feet square, were excavated in infested tobacco soil, and the larval population noted in the tobacco row as well as between rows.

Of all the larvae taken during the last three years, 64 per cent were

found in the row, directly below the tobacco plants, and 36 per cent between the rows. The following table gives the percentages of wireworm population at the various soil horizons for the past three years.

0"— 3"	9.2 per cent
3"— 6"	21.5 per cent
6"— 9"	40.7 per cent
9"—12"	23.5 per cent
12"—24"	4.9 per cent

EFFECT OF SHADE CLOTH ON LIGHT INTENSITY

Although it is obvious that the use of shade cloth over a tobacco field reduces the intensity of the sunlight and that this has a decided effect on the quality of the leaves, yet there are no published determinations of the extent of light reduction effected. In recent years improvements in instruments for measuring light intensity make it now a relatively simple matter to measure such differences accurately. A few preliminary measurements were made during July of the past season. The instrument used was the Weston Exposure Meter, a photronic cell with a voltmeter calibrated in candles per square foot.

With outdoor intensities of 800 to 1000 candles per square foot, the average reduction in the tent was 300 candles per square foot, or 34 per cent reduction. With intensities of 600 to 700 candles per square foot in the open, reductions were above 400 candles per square foot, or 64 per cent of the total intensity. On cloudy days, with intensities of 300 candles or less per square foot, the reduction was necessarily less than the total light, yet nearly 50 per cent of the total in the open. An average reduction of 50 per cent for all conditions is perhaps a fair estimate.

The significance of this difference on the physical characters of the plant is a matter of common knowledge. The leaves under shade are thinner, longer and broader, and the veins are smaller, all of which are desirable characteristics for cigar wrappers. Also the stalks are taller. We cannot say, however, that all of these changes are produced by light reduction. The shade cloth also increases the humidity and temperature, and lowers evaporation and wind movement. Just what part each of these factors plays in changing the leaf characters has not been determined.

The chemical composition is also profoundly varied. If the same strain is planted under both outdoor and shade conditions, it will be found that the shade plant is higher in total nitrogen and lower in carbohydrate than the corresponding sungrown plants. The total dry weight of leaves is not widely different for shade and direct sunlight, but the shade yield fluctuates less from year to year, due to more uniform moisture relations.

The cloth used in this test was the regular cotton shade cloth of the same grade as that used by most shade growers. It has eight strands to the inch in the warp and ten strands in the filling. It is manufactured by the Cannon Mills and is of the style designated "Style 88X improved".

QUANTITY OF SEED PRODUCED BY A SINGLE PLANT OF BROADLEAF

Inquiries are occasionally received at the Station concerning the quantity of seed that a single tobacco plant will produce. A plot on our Broadleaf field in 1934, where seed was being saved for future plantings, afforded an opportunity of making some careful measurements to answer such questions. The plants were of the Hockanum strain of Broadleaf, grown under the same conditions as plants in the rest of the field. The seed was saved in the usual way except that seed heads were covered with paper bags to prevent any accidental hybridization with other kinds of tobacco in the neighborhood. Twenty-five good plants were selected for the test. All commercially valuable leaves were harvested by priming them at the same time the rest of the field was cut. When the pods were ripe, the seed heads were cut off and hung in the curing sheds with the paper bags left in position in order to catch seed that fell out as the pods dried. In December, the number of pods on each plant was counted, and the seed threshed and weighed separately. The results for the 25 plants of this test are shown in Table 11.

TABLE 11. YIELD OF SEED FROM BROADLEAF PLANTS.

Plant Number	Number of pods	Weight (grams)
1	409	84.9
2	405	81.1
3	459	81.9
4	361	68.9
5	408	80.0
6	363	65.5
7	493	99.1
8	373	72.8
9	468	91.8
10	366	68.6
11	523	104.1
12	286	53.8
13	348	65.6
14	528	85.9
15	367	72.9
16	352	68.6
17	476	102.2
18	345	64.4
19	313	62.5
20	322	59.9
21	302	52.2
22	347	61.9
23	432	83.6
24	335	67.8
25	433	88.4
Average	392	75.5

The number of pods to the plant—averaging 392—is surprisingly large but this included all pods, regardless of size or stage of maturity. The yield of single plants varied between about 50 and 100 grams—approx-

mately from two to four ounces to the plant, with an average of somewhat less than three.

By counting the seeds in several one-tenth gram samples, the number of seeds to the gram was found to average 12,250. This figure agrees almost exactly with findings of Berthold* who conducted a Havana Seed investigation along the same line here in 1930. The average number of seeds in one pod was 2352, and the average weight was .192 grams.

From the average weight of seed per plant (75.5 grams) and the number of seeds in a gram (12,250), we find that an average plant produces 924,875 seeds.

How many acres of Broadleaf (7000 plants to the acre including replants) could be set from the seed of one seed plant? Assuming that 15 per cent of the seeds fail to germinate, and another 35 per cent are smothered out in the seed bed or fail for various reasons to make good plants, we would still have enough plants from one seed plant to set 66 acres.

*Conn. Agr. Exp. Sta. Bul. 326: 406-410. 1930.



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